Identifying Well Pads in the Haynesville Shale Region, Louisiana and Texas, with Digital Imagery

Darinda Dans
Daniel Unger
Arthur Temple College of Forestry and Agriculture, Stephen F. Austin State University, unger@sfasu.edu

Kenneth W. Farrish
Arthur Temple College of Forestry, Stephen F. Austin State University, kfarrish@sfasu.edu

I-Kuai Hung
Arthur Temple College of Forestry and Agriculture, Stephen F. Austin State University, hungi@sfasu.edu

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Abstract

The Haynesville Shale is an underlying rock formation in northern Louisiana and northeastern Texas that contains vast quantities of natural gas. With new technology, the ability to extract more natural gas from one of the largest gas deposits in the United States has increased. While increased production has impacted the local ecosystem, the Haynesville Shale is not yet known, and is continually changing due to new discoveries.

Introduction

Energy demand has risen in recent years and is expected to continue to increase. Oil and gas production is the primary source of energy and this demand intensifies efforts to increase exploration and production. Concerns of potential environmental impacts due to the exploration and production of petroleum have also increased in recent years.

While oil and gas production has occurred in the region for decades, current production has dramatically increased due to new technologies, such as hydraulic fracturing and directional drilling. Drilling in the Haynesville Shale started in 2007, with approximately 85% completed wells by October 2008. The majority (71%) of these wells were located in Louisiana.

Numerous remote sensing and GIS tools are available that aid in the study of anthropogenic activities on the Earth’s surface. Using digital analysis techniques, images are altered in a manner that visually improves the identification of well pads within the Haynesville Shale region. Two techniques studied were able to assist in better identification of well pads using multispectral imagery. When visually assessing each band of the PCA, band 4 showed the most promise for use in well pad identification. Different band combinations were also used, resulting in another way to visually identify well pads. Though clay minerals index and iron oxide index were not as useful when applied to the identification of well pads.

Study Area

The Haynesville Shale is an underlying rock formation in northern Louisiana and northeastern Texas that contains vast quantities of natural gas. The Haynesville Shale is deeper than most other shale plays at 3.1 - 4.3 kilometers (1.9 - 2.7 miles), and is approximately 91 meters (295 feet) thick. The Haynesville Shale region encompasses approximately 2,890,770 hectares (7,143,248 acres). The full spatial extent of the Haynesville Shale is not yet known, and is continually changing due to new discoveries.

Methods

The image used for analysis was a mosaic of four Landsat 5 TM images taken in August 2011. Bands 2, 4, 5, and 7 were taken August 5, 2011, and Bands 3 and 7 were taken August 28, 2011. Imagery was downloaded from the United States Geological Survey (USGS) website (http://glovis.usgs.gov/). Principal component analysis were extremely useful in visually identifying well pad locations while the effectiveness of digital ratios depended on the ratio utilized.

Results

Vegetation Indices

Indices were performed on the mosaiced Landsat TM image, and an area of Bossier Parish, LA is used below to aid in visually comparing the different bands. The identification of well pads showed promise using four different indices: difference vegetation index, normalized difference vegetation index (NDVI), ratio vegetation index, and square root transformation of the ratio vegetation index (SQRT). Clay minerals index and iron oxide index were not as useful when applied to the identification of well pads. Normalized difference vegetation index (NDVI)

Difference vegetation index is the difference of green leaf scattering in the near-infrared and chlorophyll absorption in the red. The difference vegetation index is calculated by subtracting red from near-infrared.

NDVI is the normalized difference of green leaf scattering in the near-infrared and chlorophyll absorption in the red band. NDVI is calculated using (near-infrared minus red) divided by (near-infrared plus red).

Results

Principal Component Analysis

PCA was performed on all seven bands of the mosaiced Landsat TM image. To better understand the results, an area of Bossier Parish, LA is used below to aid in visually comparing five of the seven bands. Bands 2 and 3 had the most amount of variance and were not as useful in identifying well pads. Also shown below is what was determined to be one of the best band combinations to identify well pads (bands 5-4-3).

Conclusion

Numerous remote sensing and GIS tools are available that aid in the study of anthropogenic activities on the Earth’s surface. Using digital analysis techniques, images are altered in a manner that visually improved the identification of well pads within the Haynesville Shale region. The techniques studied were able to assist in better identification of well pads using multispectral imagery. When visually assessing each band of the PCA, band 4 showed the most promise for use in well pad identification. Different band combinations were also used, resulting in another way to visually identify well pads. Though clay minerals index and iron oxide index were not as applicable in the identification of well pads, the four vegetation indices, difference vegetation index, normalized difference vegetation index (NDVI), ratio vegetation index, and SQRT, were useful in visually identifying well pads in the Haynesville Shale region.